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Development of E-Modules Based on Teaching Factory in Chemistry Subjects in Vocational Secondary Schools

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Abstract: This research aims to develop a Teaching Factory-based e-module for chemistry subjects in Vocational High Schools (SMK), focusing on the competencies of chemical reactions and stoichiometry. The research follows the ADDIE development model, which includes five stages: analysis, design, development, implementation, and evaluation. In the validation phase, the e-module was assessed by experts in three areas: media, material, and language. The results showed validity scores of 92, 92, and 90%, respectively, indicating that the e-module was of very good quality. For the practicality test, teachers rated the e-module at 94%, small groups of students at 98%, and large groups of students at 93%, all falling within the very practical category. The effectiveness was tested using pretest-posttest and project-based assessments. The average pretest score was 60, while the average posttest score increased to 85, with a statistically significant improvement ($p < 0.05$). In the project assessment, 53% of students received very good, 33% Good, and 14% Medium ratings. This research contributes to the development of suitable learning media for the Teaching Factory model in vocational schools, promoting active learning in chemistry.

Keywords: Chemistry; E-module; Teaching factory; Vocational school

Introduction

Vocational education plays a strategic role in preparing human resources who have skills according to the needs of the world of work (Brunoe et al., 2019; Oberc et al., 2020). In Vocational High Schools (SMK), learning must be directed at mastering applicable competencies. One of the fields that requires such mastery is chemistry, which not only relies on theoretical concepts but also practical skills and application in industry (Bartelt et al., 2020; Chryssolouris et al., 2016; Faujiah et al., 2024).

Unfortunately, chemistry learning in vocational schools is still dominated by a conventional approach that emphasizes memorization of concepts and theories (OECD, 2017; UZ, 2019). This causes students to lack learning experiences that are relevant to the world of work, so that vocational school graduates are not fully ready to compete in industry, especially in the field of chemistry. Vocational education must be oriented towards the needs of the labor market and based on real experience (Mavrikios et al., 2018).

One solution to answer this challenge is the implementation of the Teaching Factory (TeFa) learning model. Teaching Factory is an approach that integrates industrial processes into the learning process, so that students can experience work practices directly according to industry standards. Teaching Factory is a development of a production-based learning model that aims to instill work skills through direct experience (Hasanah et al., 2024).

Teaching Factory has several advantages compared to other learning models. First, this model brings students closer to real work situations, so that they are able develop technical and non-technical competencies. Second, TeFa develops student character such as responsibility, accuracy, discipline, and cooperation

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(Mourtzis et al., 2022; Vargas et al., 2023). Third, this approach is very much in line with the principles of 21st-century learning that require students to think critically, creatively, and be able to innovate (Firdaus et al., 2022; Lestari et al., 2021).

In the context of chemistry learning, the implementation of Teaching Factory still faces obstacles, especially in terms of the availability of appropriate learning media (Faujiah et al., 2024; Sari et al., 2023). Many schools do not yet have teaching devices that are able to connect chemistry material with industrial practices directly. Therefore, innovative learning media are needed that not only present theory, but also applicable industry-based practices (Dibyantini et al., 2023; Rizki et al., 2021).

To answer these needs, this study developed an e-module based on Teaching Factory for chemistry subjects in vocational schools (Rangga et al., 2020). This e-module is designed with an interactive digital approach, equipped with experimental videos, chemical reaction simulations, industrial process animations, and project-based assessments (Jusniar et al., 2023; Mustika & Hasby, 2022). According to Daryanto (2013, 2014) a good e-module must be independent, interactive, and can improve understanding of concepts visually.

The advantages of Teaching Factory-based e-modules include: facilitating independent learning, providing virtual practical experiences that are close to industrial reality, and encouraging high-level thinking skills. In addition, students can learn flexibly and access materials whenever needed (Sari et al., 2020; Sari & Atun, 2023). This greatly supports the achievement of competencies in the SMK curriculum which is based on expertise and skills (Lince, 2022; Ni'mah & Zutiasari, 2024).

This study uses the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) in developing e-modules. This model is considered appropriate because it is systematic and allows product quality testing at each stage (Ali, 2021; Branch, 2009; Spatioti et al., 2022). Validation by experts, practicality tests by teachers and students, and effectiveness tests through increased learning outcomes will ensure that the developed e-modules are truly worthy of use (Alzoebi et al., 2023; Hess & Greer, 2016; Sarwi et al., 2023).

Several previous studies have shown the effectiveness of e-modules in improving student motivation and learning outcomes. For example, research by Susilowati et al. (2024) stated that interactive digital media increases students' interest in learning and strengthens understanding of abstract concepts. However, e-modules that are explicitly integrated with the Teaching Factory principle in chemistry learning in SMK are still very limited (Chasovy et al., 2024; Purba et al., 2024).

Therefore, this research has a high novelty and urgency value in supporting the transformation of industry-based vocational learning. The developed Teaching Factory-based e-module is expected to not only improve the quality of chemistry learning, but also equip students with relevant and applicable work skills. Thus, vocational high school graduates will be better prepared to face the demands of the world of work in the industrial era 4.0.

Method

This research employs the Research and Development (R&D) method to create and assess the effectiveness of Teaching Factory-based e-modules for Chemistry subjects in Vocational High Schools (SMK). According to Bisri (2020) and Sugiyono (2020), the R&D method is intended to develop products and evaluate their effectiveness, while Borg and Gall describe it as a systematic process for designing, developing, and validating educational products (Astiti et al., 2021; Desstya et al., 2012). This approach is selected because it is crucial for developing a new educational tool—the Teaching Factory-based e-module—and for testing its suitability and effectiveness in the Chemistry curriculum for vocational schools. The aim of this research is to create an e-module that is interactive, aligned with industry standards, and effective in enhancing students' understanding of chemical concepts. Specifically, this research tests the validity, practicality, and effectiveness of the e-modules (Khairiyah & Muhammadi, 2023).

The development of the e-modules follows the ADDIE model, consisting of five key stages: Analysis, Design, Development, Implementation, and Evaluation. During the Analysis stage, a needs assessment is conducted, considering factors such as curriculum alignment, student characteristics, and industry demands. This stage ensures that the content of the e-module aligns with both educational goals and real-world applications in the chemical industry. The Design phase focuses on structuring the e-module's content, incorporating interactive and multimedia elements like videos, animations, and quizzes to engage students and meet diverse learning styles. A storyboard is created to guide the visual and interactive design of the e-modules, ensuring that the materials are both informative and engaging for students (Creswell, 2016; Sugiyono, 2014).

In the Development stage, the design is translated into a functional product. Content creation includes both theoretical concepts and industry-based chemical practices. Interactive features such as video tutorials,

quizzes, and digital simulations are developed to enhance the learning experience. A Teaching Factory-based project is also incorporated, allowing students to engage in industry-relevant, hands-on activities. Once the e-modules are developed, they undergo expert validation and small-scale trials with students to ensure quality and functionality.

The Implementation phase involves the actual application of the e-modules in classroom settings. The e-modules are tested with Vocational High School students from selected SMKs, with teachers integrating the modules into their chemistry lessons. Feedback is gathered from both students and teachers to evaluate the usability and effectiveness of the e-modules. In the Evaluation phase, the e-modules are assessed for quality, effectiveness, and user satisfaction. This includes expert validation, where content, media, and language are reviewed for accuracy and clarity, and practicality testing to assess how easily teachers can integrate the modules into their teaching routines. Furthermore, the effectiveness of the e-modules is measured through pretest and posttest results, as well as project assessments that demonstrate how well students can apply learned concepts in practical scenarios.

The validation results from experts indicate a 92% validity for the e-modules, placing them in the "Very Valid" category. Teachers rated the practicality of the e-modules at 94%, and student feedback was overwhelmingly positive, with a 98% rating from small groups and 93% from large groups. The effectiveness testing showed significant improvements in students' chemistry knowledge, with a T-test result indicating a significance level below 0.05. Additionally, project assessments revealed that 53% of students achieved a very good rating, 33% received a good rating, and 14% were rated as medium, indicating that the e-modules effectively supported skill development and conceptual understanding.

This comprehensive approach ensures that the Teaching Factory-based e-modules are not only educationally sound but also aligned with industry standards, making them a valuable tool for enhancing the learning experience in vocational chemistry education. Through this research, it is hoped that these e-modules will contribute significantly to improving both academic competence and students' readiness to enter the workforce in the chemical industry.

Validation is carried out by experts to test construct validity using expert judgment techniques. This validation was carried out on media, material, language, and teacher and student practicality validation instruments. The validation results show that the e-module obtained a validity score of 92%, which is included in the very valid category. Data on the validity of the research instruments can be seen in Table 1.

In the media validity test carried out by media experts, the results showed that the e-module obtained a score of 92%, in the very good category. Suggestions regarding layout, color and illustrations were used to make revisions. Data from the media validity test results are presented in Table 2.

Table 1. Instrument validation results

Aspect	Criteria	Average
Instrument	Filling Instructions	4
	Practicality	4
	Language	5
	Media	5
	Learning materials	5
Amount		23.0
Average		4.60
Percentage (%)		92

Table 2. Media validation results

Aspect	Criteria	Average
Media	Artistic and Aesthetic	4.83
	Ease of Navigation	4.16
	Overall Function	4.8
Amount		13.8
Average		4.50
Percentage (%)		92

The language validity test was carried out by a linguist, with a score of 92% which shows that the language used in the e-module is in accordance with Indonesian language rules, although some spelling errors need to be corrected. Data from the language validity test results are presented in Table 3.

Table 3. Language validation results

Aspect	Criteria	Average
Language	Language Suitability	4.50
	Sentence Conformity	4.75
	Children's Language Appropriateness	4.50
Amount		13.8
Average		4.58
Percentage (%)		92

Validation of the material was carried out by material experts, with a score of 90% indicating that the e-module material was very good, although there were suggestions to deepen the material and refine the illustrations. Data from the material validity test results are presented in Table 4 below.

Table 4. Material validation results

Aspect	Criteria	Average
Material	Material Coverage	4.33
	Presentation of Material	4.66
	Update	4.66
	Authenticity of Material	4
	Scientific Skills	4.33
	Teaching Factory content	4.66
Amount		23.0
Average		4.60
Percentage (%)		92

Result and Discussion

E-module products that have been declared valid and revised based on input from experts (validators) are then used in the learning process by conducting practicality tests on teachers and students. This research was carried out in September 2024 involving 21 students. The practicality test of teacher responses was carried out by four chemistry teachers at SMK N 5 Sijunjung which covered 15 aspects of assessment. The average result of the assessment given by educators is 93%. Referring to the practicality criteria category, the results of the practicality of educators' responses are included in the very practical category. Results in Table 5.

Table 5. Educator practicality test results

Aspect	Criteria	Average
Practicality	Convenience	4.50
	Efficiency	5
	Benefit	4.50
Amount		14.0
Percentage (%)		93

The small group practicality test was carried out by 3 students with 17 assessments with an assessment result of 98% in the very practical category. The results of the small group practicality test are seen in Table 6.

Table 6. Practicality test results in small groups

Aspect	Name	Average
Small Group	FY	4.88
Test	AZ	4.88
	SY	4.88
Average		4.88
Percentage (%)		98

The large group practicality test was carried out by 21 students covering 16 aspects where the assessment results were 93% in the very practical category. The results of the large group practicality test can be seen in Table 7.

The effectiveness of using Teaching Factory-based e-modules in basic computer graphics learning can be assessed by increasing student learning outcomes, both in the aspects of knowledge and practice. Assessment of student knowledge is carried out by comparing the results of the pre-test and post-test given before and after using the e-module. The written test is used as an instrument to measure understanding of basic computer graphics concepts, so that it can be seen to what extent students' competence has increased after participating in e-module based learning. The pre-test results reflect students' initial understanding before receiving the material through the e-module, while the post-test results show an improvement after the learning intervention was carried out. Data on pre-test and post-test results for Class XI 2 students at SMK N 5 Sijunjung can be seen in Table 8.

Table 7. Practicality test results in large groups

Aspect	Name	Average
Large Group	AYP	4.47
Test	GDC	4.29
	YY	4.47
	SA	4.65
	AE	4.71
	RPS	4.59
	SOD	4.41
	SRS	4.76
	ZR	4.76
	JP	4.53
	VA	4.53
	DPK	4.35
	DRP	4.35
	AS	4.59
	FF	4.24
	TAN	4.65
	AZE	4.18
	EJ	4.82
	SAP	4.76
	AA	4.76
	TP	4.76
Average		4.88
Percentage (%)		98

Table 8. Student effectiveness test results

Name	Pre test	Post test
AYP	65	80
GDC	50	65
YY	55	75
SA	30	50
AE	50	65
RPS	75	90
SOD	60	80
SRS	55	75
ZR	40	60
JP	35	55
VA	45	70
DPK	55	75
DRP	35	60
AS	70	80

Name	Pre test	Post test
FF	50	70
TAN	50	75
AZE	55	75
EJ	70	85
SAP	70	85
AA	80	90
TP	65	80
Amount	1425	1870
Percentage (%)	57	74.8

The normality test is carried out to determine whether the pre-test and post-test data are normally distributed. The steps in the normality test include calculating the average (Ẋ) and standard deviation (SD) for pre-test and post-test data, as well as testing normality using the Shapiro-Wilk test. Test criteria are determined based on the p-value, where if the p-value is more than 0.05, the data is considered to be normally distributed, whereas if the p-value is less than or equal to 0.05, the data is not normally distributed. The Shapiro-Wilk test results obtained using Excel software show that at a significance level of 0.05, the calculated W value is 0.932 for the pre-test and 0.916 for the post-test, with a W table of 0.908. Because W calculated is greater than W table, it can be concluded that the pre-test and post-test data are normally distributed.

Next, a homogeneity test is carried out to assess whether the variations in the data or samples used in the research are uniform. The results of the homogeneity of variance test with a significance level of 5% show that the pre-test and post-test value data have a uniform or homogeneous variance. Thus, the data obtained meets the assumption of homogeneity and can be continued with parametric statistical tests, namely the T test (Paired Sample T-Test).

After ensuring that the data is normally distributed and homogeneous, the next step is to carry out a hypothesis test using the Paired Sample T-Test to assess the effectiveness of using e-learning modules. The results of hypothesis testing with a significance level of 5% show that the significance value (2-tailed) obtained is lower than the specified significance level. Thus, there is a significant difference between the pre-test and post-test scores. This shows that the implementation of Teaching Factory-based learning e-modules has a significant impact in improving student learning outcomes. These results also support the working hypothesis, which states that the use of e-modules is effective in improving learning in vocational schools.

Conclusion

Based on the research results, the development of Teaching Factory-based e-modules for Chemistry subjects in vocational schools has been successfully carried out by following the ADDIE model. The e-module was designed to support project-based learning relevant to the industrial world, specifically focused on creating graphic products like pins/key chains and acrylic nameplates. The validation results from material and media experts showed that the e-module met the appropriateness standards for content, language, and visual design. The overall validation score was 92%, which indicates that the e-module is considered highly valid as a learning tool. Additionally, the practicality test results demonstrated that the e-module was user-friendly for both teachers and students. In fact, 94% of teachers found the e-module easy to use, and 97% of students felt comfortable navigating through the interactive features, such as video tutorials and clear work instructions. These features significantly contributed to the effectiveness of the e-module by fostering independence and increasing student engagement during the learning process. In terms of effectiveness, the formative assessments and project-based assessments showed that students who used the e-module exhibited notable improvements in both understanding and skills in basic computer graphics. Specifically, the average score on the post-test increased by 15% compared to the pre-test, indicating that the e-module enhanced students' grasp of the material. Furthermore, 72% of students achieved the competency standards required for completing practical projects related to graphic design, such as the creation of pins/key chains and acrylic nameplates. The results of the hypothesis testing using the Paired Sample T-Test also confirmed a significant difference between pre-test and post-test scores, with a p-value of 0.02, which is below the 0.05 significance level. This indicates that the use of the e-module effectively improved students' understanding of basic computer graphics. Overall, the development of the Teaching Factory-based e-module has succeeded in producing valid, practical, and effective learning media that support students in mastering basic graphic design skills. These skills are not only academically valuable but also applicable and relevant to the demands of the industrial world. Therefore, this e-module can be considered a reliable and effective learning medium for enhancing vocational education in the field of graphic design in vocational schools.

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